

**THE DISSEMINATION AND USE OF CLIMATE  
FORECASTS FOR IMPROVED MANAGEMENT OF  
WILDLIFE CONSERVATION AND PROMOTION OF  
TOURISM IN KENYA**

**By**

**Nzioka J. Muthama, J. Githaiga and S. Manegene**

**FINAL PROJECT REPORT**

# **Abstract**

Wildlife conservation, and thus tourism, is a function of society's capacity to manage the interaction between human activities and the physical and biological environment in ways that safeguard and promote tourism but do not threaten the integrity of natural systems on which the physical and biological environment depends.

Given the interactive nature of the climate system and the biological environment it is imperative that optimal manipulation of the tourism industry, with respect to wildlife conservation, must be closely linked to prompt and appropriate utilization of climate forecasts. As the authority charged with wildlife conservation in Kenya, Kenya Wildlife Services (KWS) would greatly benefit by utilizing climate forecasts for effective management, personnel deployment and forward planning to avert economic losses arising from climatic variability. Continuous incorporation of the climate factor into the wildlife management practices would enhance sustainable utilization of the resource.

This project sought to evaluate the level of usage of climate predictions in Kenya for purposes of effective wildlife management for tourism industry.

The processes of actual usage of the relevant disseminated and understandable forecasts by KWS in non-existent, according to a survey in KWS. However, the issue of human-wildlife conflicts is seen as ranking high in the weather related factors of importance to KWS.

Monthly data on human-wildlife conflict parameters in Kenya were collected. Thirty years of monthly rainfall data for stations representing five Kenyan climatic homogeneous zones where national parks are situated were also collected.

The data were grouped into six categories, namely: according to types of animals, reported injuries to humans, deaths of humans, death of domestic animals, crop destruction sites, and names of affected locations. These categories were analyzed for any temporal variability. Results of the analysis indicated that the variability of the number of types of animals involved in these conflicts are dependent on rainfall.

Also the number injuries and deaths of both human beings and domestic animals follow rainfall patterns. In addition, the numbers of sites where crops are destroyed by wildlife, together with the numbers of cases of crop destruction, also depict a seasonal pattern, which is related to that of rainfall. The dry season of June to August seems to be the most sensitive to these human-wildlife conflict parameters. Analysis of the relationship between the dynamics of these conflict parameters and rainfall indicated that rainfall at Nyeri and Narok is negatively correlated with all the parameters except the death of humans. Rainfall was found to lead these categories with at least three months. Narok rainfall portrays a potential of being useful as an index for human-wildlife conflict prediction and monitoring in Kenya. These relationships can, therefore, be further quantified with an aim of projecting them forward in time with a reasonable skill. Such modeling would be useful for factoring in rainfall information into the planning process of the KWS.

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# INTRODUCTION

As of 1992, a total of 44,928 Km<sup>2</sup> or about 8% of Kenyan land area was protected as National Parks and Reserves, spread in different geographic and climatic regions. Outside this area, wildlife occurs in other rangeland areas under communities and private landowners where its conservation and related activities play an important role in the local economies. Wildlife management, conservation and tourism related industries have emerged as one of the leading foreign exchange earners in Kenya. Wildlife conservation, primarily the system of National Parks (numbering 26) and Reserves (numbering 30) are under the management of Kenya Wildlife Service (KWS) and Local Authorities. KWS plays a great role in the management of wildlife in these protected areas as well as having the National mandate to oversee wildlife conservation in the non protected areas.

Outside this system of parks and reserves, pastoral communities inhabit rangelands constituting 80% of Kenya, with their livestock co-occurring with wildlife. An influx of rain-fed agricultural practices in these marginal areas has further complicated the social and economic setup in these regions. A large proportion of the protected areas, is coincidentally found in the range land areas. The majority of National Parks are not fenced, and there is free movement of wildlife, livestock and pastoralists between the protected and adjacent areas.

Most of the wildlife conservation areas are characterized by variable climatic conditions that dictate the vegetation dynamics, wildlife movements and migrations as well as the activities of the pastoral communities and their livestock. The climatic variability and consequent effects have serious implications on wildlife conservation and economic activities through effects on:

- Functioning of ecosystems (lakes, rivers, etc).

- Forage production and water resources
- Wildlife movements and migrations
- Tourism destinations and accessibility
- Human wildlife interactions and subsequent losses through human death, injuries, livestock and wildlife kills, crop raiding etc.
- Wildlife Conservation and socio-economic activities in affected areas

Climate interacts with other aspects of the physical environment determines the environmental conditions prevailing in a given area. Wildlife conservation and tourism are based on the predictability and stability of climatic conditions. Tourism in Kenya is largely based on wildlife, which is very vulnerable to climatic variability. The variability affects the vegetation and the wildlife directly. Climatic fluctuations result in major economic losses in the tourism industry arising from:

- Disrupted tourist schedules
- Wildlife species deaths
- Fire outbreaks and losses in equipment, financial resources and man hours for control
- Infrastructure destruction through flooding
- Increased human wildlife interactions with concomitant losses

Wildlife conservation, and thus tourism, is basically a function of society's capacity to manage the interaction between human activities and the physical and biological environment in ways that safeguard and promote tourism but do not threaten the integrity of natural systems on which the physical and biological environment depends.

Climate generally encompasses seasonal temperature, humidity, radiation and precipitation patterns, which affect biological systems. This requires the understanding of interactions between the various systems and ensuring continued availability of environmental resources (such as soil, fresh water, biodiversity, clean air, etc).

The terms conservation (protection and rational use) and management both imply the sustainable utilization of resources. Wildlife conservation is, however, wholly dependent on effective management of biological environment whose spatial and temporal characteristics can be discerned and projected through climate prognosis

Given the interactive nature of the climate system and the biological environment it is imperative that optimal manipulation of the tourism industry, with respect to wildlife conservation, must be closely linked to prompt and appropriate utilization of climate forecasts. As the Authority charged with wildlife conservation in Kenya, KWS would greatly benefit by utilizing climate forecasts for effective management, personnel deployment and forward planning to avert economic losses arising from climatic variability. Continuous incorporation of the climate factor into the wildlife management practices would enhance sustainable utilization of the resource.

### ***Aim of the study:***

The general objective of the work is to evaluate the level of usage of climate predictions in Kenya for purposes of effective wildlife management for tourism industry. The specific objectives include:

- Assessment of the current mode, extent of usage and application of climate forecasts by KWS in Wildlife management; and the consequent possible implications on Kenya's tourism industry.
- To carry out a survey on the impacts, on KWS and tourism industry, of anomalously wet and dry 1997/1998 and 1999/2000 periods, respectively. The survey was carried out in the context of disrupted tourist schedules; Wildlife

species deaths; Fire outbreaks and losses in equipment; financial resources and man hours for control; Infrastructure destruction through flooding; and Increased human-wildlife interactions with concomitant losses.

- Initiation of mechanisms for integrating climate forecasts into wildlife management and conservation, tourism industry and related economic activities.

### ***Problem under consideration:***

The utilization of climate forecasts and outlooks in decision making for improved wildlife conservation, management and the tourism industry in Kenya still remains poorly documented. This work seeks to address this issue by examining current state of affairs and studying the implications of including climate forecasts into the routine decision making mechanisms for enhanced effectiveness of wildlife conservation and tourism promotion.

## **Methodology**

### ***Materials and methods***

A survey was carried out on major impacts of extreme climate on wildlife in Kenya. The scope of the study entailed the National parks and their environs where the impacts of droughts and floods are usually devastating. Data on human-wildlife conflicts were collected for the period 1997 to 2002. The survey regarding the impacts was carried out for

- (I) The wet 1997/1998 period,
- (ii) The relatively dry 1999/2000 period, and
- (iii) A relatively normal period of 2000 to 2002.

The survey data included:

(a) *Increased human- wildlife conflicts with concomitant losses*

Monthly data on where the wild animals were involved in the conflict and the subsequent impacts are given. The data were categorized into four groups:

- i. According to types of animals,
- ii. Reported injuries,
- iii. Deaths of humans,
- iv. Death of other animals,
- v. Crop destruction sites, and
- vi. Names of affected locations.

The data sets were tabulated on yearly basis (Tables 1 to 6).

Month	Location	Animal	Impact
January	Malindi, Lake Victoria, Busia, Athi river	Crocodiles	4 persons killed
February	Sambururu, Taita Taveta	Elephants, Crocodiles	2 people killed
March	Busia, Kwale	Crocodiles, Lions and Rhinos	26 goats and 2 cows killed
	Isiolo	Lions	2 injured
April	Turkana	Hyena	5 people injured
May	Limuru	Leopards	5 sheep killed,
June			
July			
August	Marsabit	Lions	80 heads of cattle killed
September	Limuru	Elephant	1 person killed
October	Uasin Gishu, Nyeri	Elephant, unknown killer	100 sheep killed, crops destroyed.
November			
December			

Table 1: Human-wildlife conflict parameters for the year 1997

Month	Location	Animal	Impact
January			
February			
March			
April	Nyamira	Leopard	11 injured
May	Central Kenya	Jumbo	crops destroyed
June	Kwale	Elephants	crops destroyed
	Narok	Zebras, Buffalos, Antelopes,	102 goats killed, crops destroyed
	Kwale	Crocodiles	1 person killed
July	Keiyo	Elephants	crops destroyed
	Mariakani	Hippo	crops destroyed
August	Bondo	Crocodile	2 people killed
September	Machakos	Buffalo	2 people injured
October	Kericho	Elephant	1 people injured, 1 killed
November	Makueni	Crocodile	6 killed, 14 injured
December	Kirinyaga	Buffalo	20 people injured
	Wajir	Lion	36 heads of cattle killed

Table 2: Human-wildlife conflict parameters for the year 1998

Month	Location	Animal	Impact
January	Wajir	Lions	2 killed, 20 heads of cattle killed
	Taveta	Lions	5 goats, 1 cow killed
	Nyando	Hyena	3 sheep, 3 dogs killed
February	Isiolo	Wild animals	2 people killed
March	Isiolo	Jumbo	1 person killed
April	Mariakani	Hippos	1 person attacked
May	Laikipia	Jumbo	1 person hurt
	Njoro	Jumbo	2 people killed
	Kinangop	Hippo	4 people hurt
	Lake Nakuru National Park	Lion	20 cows killed
June	Mt. Kenya Forest, Kirinyaga	Elephant	1 person killed, 1 injured

<b>July</b>	<b>Nandi</b>	<b>Hyena</b>	<b>1 person injured</b>
	Laikipia	Elephant	2 people killed
August			
September	Taveta	Jumbo	crops destroyed
	Marsabit	Hyena	17 cows killed
	Kwale	Jumbo	crops destroyed
	L. Naivasha	Hippo	farm destroyed
October			
	Lamu	Elephants	farming activities disrupted
	Nakuru	Zebra	10 families displaced
	Nakuru	Jumbo	20 farms destroyed
November			
December			

Table 3: Human-wildlife conflict parameters for the year 1999

<b>Month</b>	<b>Animal</b>	<b>Location</b>	<b>Impact</b>
January	Elephants	Kwale	crops destroyed
February	Jumbos	Narok	1 person killed
March			
April	Lion	Narok	30 injured, 1 person killed
	Elephant	Tharaka	1 person killed
May	elephant	Narok	1 person killed
June	elephant	Samburu	2 people killed
	Leopards	Uasin Gishu	6 people injured
	Jumbo	Narok	crops destroyed
July	Hippo	Malindi	crops destroyed
	Hyena	Nandi	1 person killed
	Elephant	Rumuruti, Nyeri	6 person killed
	Elephant	Turkana	crops destroyed
	Elephant	Laikipia	1 person killed
	Elephant	Kwale	1 person killed
August	Elephant	Kajiado	1 person killed, 40 farms destroyed
	Monkey	Mandera	5 injured
	Hyena	Kwale	2 killed
	Baboons	Laikipia	300 goats killed
	Buffalo	Laikipia	crops destroyed
September	Jumbo	Narok	crops destroyed
	Hippo	Hola	1 person injured
	Birds	Uasin Gishu	Quella quella birds, crops destroyed

	Giraffes	Uasin Gishu	Crops destroyed
October	Buffalo	Nyeri	>100 baboons destroy crops
	Elephant	Samburu	2 killed by herd of elephants
	Jumbo	Taita Taveta	>100 elephants destroy crops
November	Jumbo	Central Meru	1 person killed, crops destroyed
December	Elephant	Nyandarua	2 people killed
	Hippo	Kisumu	1 person killed
	Hyena	Narok	2 people killed, some livestock killed
	Crocodile	Kwale	1 person killed
	Hyena	Garissa	1 person killed, 6 camels and 31 goats killed

Table 4: Human-wildlife conflict parameters for the year 2000

Month	Location	Animal	Impact
January	Wajir	wildlife	300 livestock killed - drought
	Laikipia	Jumbos	Crops destroyed
	Kitui	Hippo	2 people killed
	Kwale	Buffalo	1 person killed
	Kwale	Elephant	1 person killed
February	Nyeri	Monkeys	Crops destroyed
	Laikipia	Hyena	1 person killed
	Guwahati	Elephants	4 people killed
March	Meru central	Jumbos	Crops destroyed
	Marsabit	hyenas	Many donkeys and goats killed
	Kitui	crocodile	1 person injured
April	Kilifi	Jumbos	Crops destroyed
	Nyeri	Jumbos	Crops worth millions of shillings destroyed
May	Wajir	1 Lion	1 person injured, 1 camel killed
	Narok	Jumbos	Crops destroyed
	Narok	Zebra	Crops destroyed
	Laikipia	Jumbos	1 person killed
	Mt Elgon	Buffaloes	Crops destroyed
June	Naivasha	Buffalo	1 person killed
July	Narok	Elephants	20 goats killed
	Laikipia	Jumbos	> 300 residents demonstrate
	Laikipia	Jumbos	1 person killed
	Kilifi	20 elephants	Crops destroyed valued at 0.5 million
	Kilifi	15 buffaloes	“
	Narok	Leopard	120 goats and sheep killed
	Kericho	elephant	1 person killed

August	Narok	Jumbos	6 injured in 2 months
	Voi, Taita Taveta	Jumbos	4 cows killed
	Naro Moru	Elephants	Crops worth millions of shillings destroyed
	Taita Taveta	Elephant	1 person killed
	Taita Taveta	Elephant	1 person killed (tourist)
	Kajiado	Lions	12 ostriches, 113 goats, 9 cows, 3 donkeys and 8 dogs killed
September	Nyeri	Groups of 30 Buffaloes	Crops destroyed
	Laikipia west	Jumbos	Crops destroyed
	Taita Taveta	Jumbos	Crops destroyed
	Busia	crocodile	1 person killed
October	Bondo	Hippos	6 people killed in 3 months
	Kangundo	Hippo	Crops destroyed
	Taita Taveta	Hyena	1 person killed (tourist)
	Kangundo	Buffalo	Crops destroyed
	West Pokot	crocodile	1 person killed
	Nakuru	Buffalo	1 person killed
November	Kangundo	Hippos	
		Buffalos	
	Samburu		
	30 elephants		1 person killed
	Nyando	Monkeys	Crops destroyed
	Kilifi	40 elephants	Crops destroyed
December	Shimba hills	600 elephants	Crops destroyed
	Taita Taveta	150 Jumbos	> 100 acres of crops destroyed
	Lang'ata	20 Baboons	
	Taita Taveta	>100 elephants	Crops destroyed

Table 5: Human-wildlife conflict parameters for the year 2001

Month	Location	Animal	Impact
January	West Pokot	Jumbo	1 person injured
	Kilifi	40 Jumbos	200 palm trees destroyed
	Laikipia	600 elephants	Residents demonstrate
	Turkana	200 elephants	Crops destroyed, people demonstrate
	Nyando	Hippos	1 killed
	Laikipia	Elephants	1 person killed, 10 acres of orange farm destroyed
February	Transmara	Jumbo	1 person killed, 1 person injured, crops destroyed
	Taita Taveta	Buffalo	1 person killed
March	Kabarnet	Jumbo	Farm invaded in search for water and food
	Laikipia	Jumbos	20 stores destroyed
	Kirinyaga	Jumbos	1 person injured

April	Siaya	Baboons	Property destroyed
May	Taita Taveta	200 Jumbos	Several hectares of crops destroyed
	Kajiado	Lions	36 ostriches killed in farm attack valued at Ks. 1m.
	Samburu	Leopards	2 people killed, 23 camels killed
	Nyahururu	Hippo	
June	Voi, Taita Taveta	Lion	53 sheep, 7 goats and 1 dog killed
	Laikipia	Jumbo	1 person killed
	Taita Taveta	Jumbos	Crops destroyed
	Taita Taveta	Buffalos	Crops destroyed
	Nyeri	Giraffe	1 person killed
	Narok	elephants	> 100 acres of crops destroyed
July	L. Nakuru N. Park	Lion	1 person killed (park warden)
	Samburu	elephants	>100 elephants destroy 500 acres of crops
	Narok	Lions	2 people injured, 2 cows killed
	Narok	Jumbo	>100 acres of crops destroyed
	L. Naivasha	Hippo	
August	Laikipia	Jumbo	Crops destroyed
September	Taita Taveta	Jumbos	Crops and water pipes destroyed
	Ol-Pjeta ranch	Jumbo	1 person killed
	Taita Taveta	Lion	11 cows, 3 goats, 1 sheep killed
	Taita Taveta		1 person killed, 100's of acres of crops destroyed

Table 6: Human-wildlife conflict parameters for the year 2002

In order to investigate the relationship between dynamics of animal types and weather patterns, national parks were related with homogeneous climatic zones. Rainfall was chosen as representative of weather parameter, which affects wildlife. Thus rainfall stations were selected from four homogeneous climatic zones, representing regions with reported animal types dynamics data (see Figure 1 below). They included Nyahururu, Voi, Nyeri, Narok, and Kilifi. Simple correlation analysis was performed on rainfall versus animal types.



Wildlife- human conflict is connected to availability (or lack) of food for the wildlife. In turn vegetation growth is dependent on rainfall. In this connection, the above mentioned six data categories are analyzed according to the dry and wet seasons of the year, namely: December, January and February (DJF), March April and May (MAM), June July and August (JJA), September and October and November (SON). Each category was analyzed separately as follows (see Table 7):

### ***Types of animals***

Temporal variability of number of the different types of animals involved in human-animals conflicts were investigated. Based on the six years of the collected wildlife-human conflict data, the JJA season seems to have the highest count of the different type of animals as shown in Figure 2. In addition, the years 1997 and 1998 had the lowest number of animal types. The period 2000 to 2001 had the highest number of types of animals. This may be associated with the above normal rainfall experienced in 1997 and 1998. This provided for enough food for the animals during 1997 and 1998.

The opposite is true for the period 2000/2001. The peak in JJA is attributable to the fact that during the years of below normal rainfall, the poor rains during the MAM rainfall season negatively impacts on the availability of food to both herbivores and carnivores to the extent that they have to wander beyond the boundaries of the national parks and hence conflicts result. In order to investigate the relationship between weather patterns and temporal behavior of number of different types of animals and weather patterns, national parks were studied with respect to homogeneous climatic zones. Rainfall was chosen as one of the key meteorological parameter affecting wildlife. The rainfall data of the rainfall stations thus selected, Nyahururu, Voi, Nyeri, and Narok, were correlated with data on number of different animal types (Table 8).

		<b>C1</b>	<b>C2</b>	<b>C3</b>	<b>C4</b>	<b>C5</b>	<b>C6</b>
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1997	DJF	3	0	8	0	0	6
	MAM	5	7	0	33	0	5
	JJA	1	0	0	80	0	1
	SON	2	0	1	100	1	3
1998	DJF	0	0	0	0	0	0
	MAM	2	11	0	0	1	2
	JJA	6	0	3	102	4	6
	SON	3	17	7	0	0	3
1999	DJF	4	1	4	70	0	6
	MAM	2	6	6	20	0	6
	JJA	3	2	3	0	0	4
	SON	4	0	0	17	6	7
2000	DJF	3	0	1	0	1	2
	MAM	2	30	3	0	0	3
	JJA	6	11	10	300	4	14
	SON	5	1	4	0	6	8
2001	DJF	6	0	16	339	2	13
	MAM	6	2	1	5	6	10
	JJA	4	6	5	286	2	14
	SON	6	0	11	0	7	16
2002	DJF	4	2	5	0	7	10
	MAM	5	1	3	59	2	8
	JJA	5	2	5	63	6	12
	SON						

Table 7: Patterns of wild animals conflicting with humans during the four seasons of the given year. C1 to C6 represent types of animals (C1), injuries of humans (C2), deaths of humans (C3), death of domestic animals (C4), crop destruction sites (C5), and names of affected locations (C6), respectively.

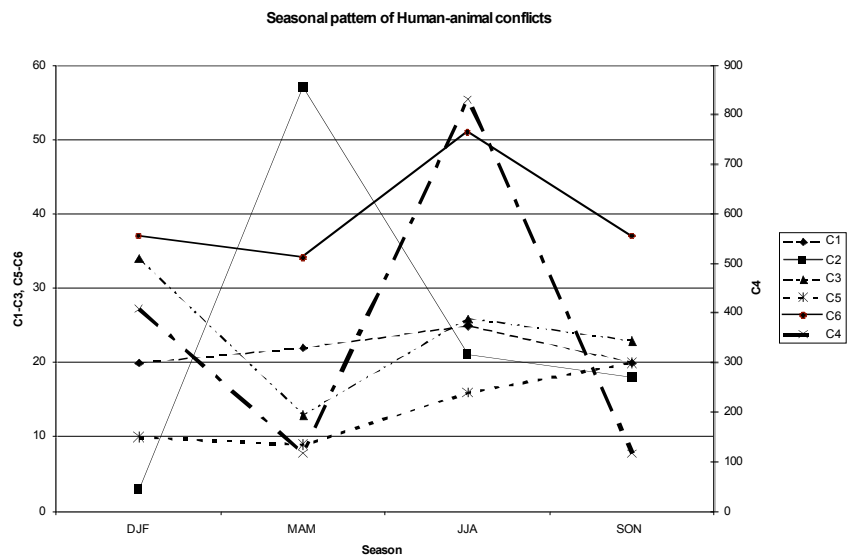


Figure 2: Seasonal pattern of Animal types

The monthly totals of animals involved in conflicts were correlated with rainfall amounts for the various stations. Nyeri and Narok showed significantly negative correlation with lags of one and two seasons, respectively (Figure 3). This agrees with the expectation that during below normal rainfall large number of different types of animals get involved in human-animal conflict. It is imperative from the results that the prevalence of the number of different types of animals involved in human-animal conflicts is inversely proportional to rainfall, especially over three out the four climatic homogeneous zones.

These results have a predictive value with a lead time of around three months. This is may be useful information for planning in KWS.

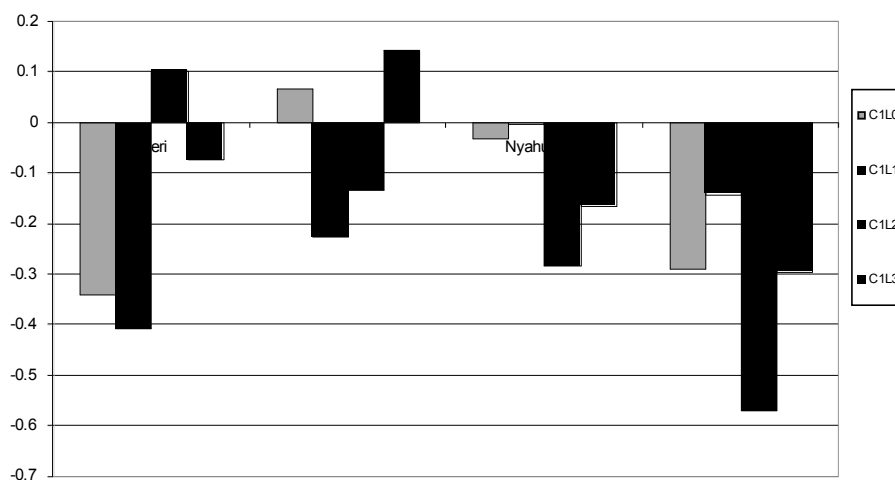


Figure 3: Animal types

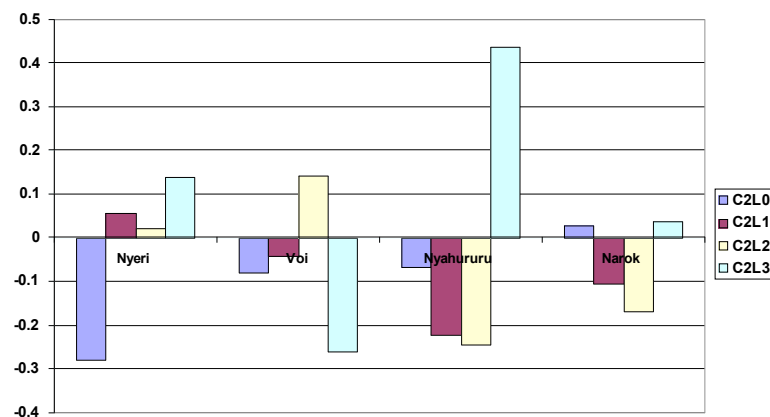
### ***Injuries to humans***

Incidences of injuries to humans due human-animal conflicts were investigated. Figure 2 shows that MAM season has the highest count of such injuries. Further research is necessary in order to establish the reason for the peak. The years 1997 and 1998 had the lowest number of such incidences. This may be associated with the above normal rainfall experienced in 1997/1998 such that there was enough food for the animals within the parks. The highest incidences occurred during 2001 and 2002, a period characterized by relatively low rainfall characteristics. The incidences of injuries to humans were correlated with

rainfall as shown in Table 8. Nyahururu rainfall showed a positive correlation counts of injuries to humans (Figure 4). Further investigation with more data is necessary to improve our understanding on this relationship.

		Nyeri	Voi	Nyahururu	Narok
Animal types	lag 1	<b>-0.40813</b>	-0.22653	-0.00146	-0.14142
	lag 2	0.104104	-0.13373	-0.28383	<b>-0.57027</b>
	Lag3	-0.07282	0.143722	-0.16461	-0.29467
Injuries- Humans	lag 1	-0.2806	-0.08069	-0.06847	0.029097
	lag 2	0.057195	-0.04321	-0.2225	-0.10586
	Lag3	0.021689	0.143336	-0.24542	-0.16889
Deaths - humans	lag 1	<b>-0.3656</b>	0.087432	-0.03634	-0.0202
	lag 2	-0.26039	0.070732	0.017426	-0.11798
	Lag3	-0.15917	-0.10012	0.029469	<b>-0.37418</b>
Deaths - other animals	lag 1	-0.09718	-0.04974	<b>0.358497</b>	-0.18614
	lag 2	-0.07029	-0.16227	-0.22524	0.010097
	Lag3	-0.09644	-0.15112	-0.06899	-0.31174
crop destruction cases	lag 1	-0.02824	-0.09979	-0.10133	<b>-0.43175</b>
	lag 2	-0.28236	-0.24211	0.291217	-0.24515
	Lag3	0.030244	-0.26768	-0.24916	<b>-0.50189</b>
affected locations	lag 1	-0.32555	0.02824	0.063551	-0.32758
	lag 2	<b>-0.36566</b>	-0.08372	0.022223	-0.16806
	Lag3	-0.13658	-0.13463	-0.25676	<b>-0.54377</b>

Table 8: correlation between human-animal data and rainfall



**Death of**

Figure 4: Injuries to humans

**human beings**

Analysis of seasonal patterns of reported deaths of humans due to wildlife-human conflicts showed the DJF season as having the highest count (Figure 2). More

investigations will explain this occurrence. The period with lowest counts was 1998 and 1999. The highest cases were reported in the 200/2001 period.

Significantly negative correlation between number of deaths of human beings and rainfall were observed for Nyeri, Nyahururu and Narok stations, with zero, three and two seasons lag, respectively (Figure 5). This indicates that during below normal rainfall more people lose their lives due to human-animal conflict than otherwise. Again, as in the case of types of animals, these results have a predictive power with a lead-time of about six months. This is useful information for planning in KWS.

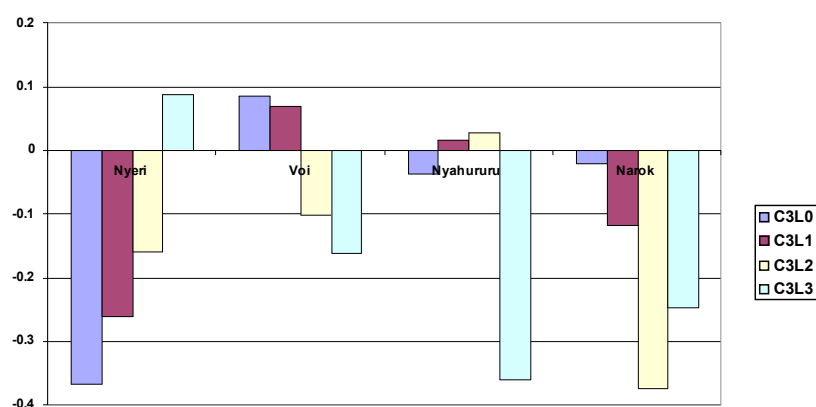


Figure 5: Death of humans

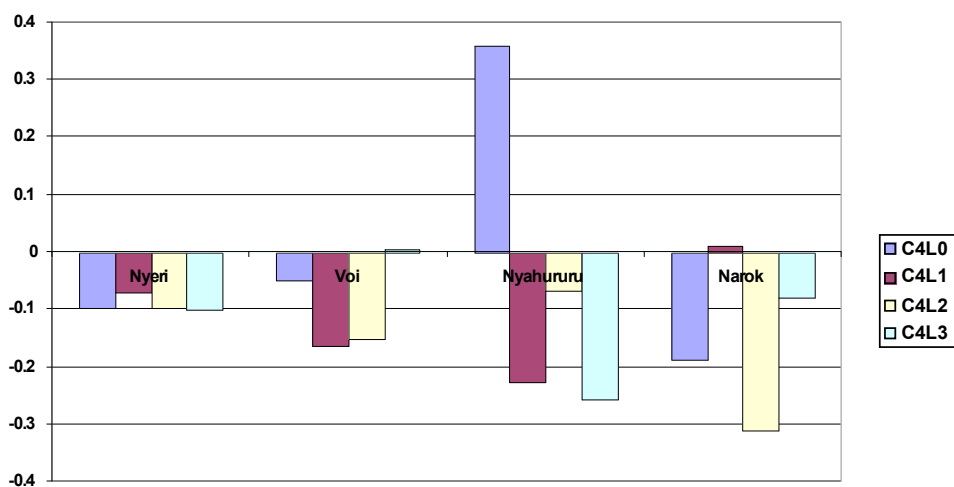
### ***Deaths of domestic animals***

Analysis of Seasonal patterns of death of domestic animals due to the human-wildlife conflicts showed that the JJA season had highest numbers (Figure 2). In deed both dry seasons had comparatively higher cases than the wet seasons. The JJA maxima in number is attributable to the fact that rainy seasons act to indirectly provide food in such quantities that few animals stray into human settlements and hence few domestic animals are killed.

Annual variability of these reported deaths depicts that, in addition, the years 1998 and 1999 had the lowest deaths. 200/2001 period had the highest cases. This is

connected to the above normal rainfall experienced in 1997/1998 whereby there was enough food for the animals. The contrary is true for the dry period 2000/2001 when the cases are highest.

Correlation between rainfall and the cases of deaths (Table 8) indicated that Nyahururu rainfall was significantly positively correlated to these cases (Figure 6). These results portray tangible utility for planning purposes in view of the predictive potential with lead-time of several months. Further investigation will explain the positive correlation.



**Figure 6: Death incidences of domestic animals**

## Crop destruction sites

The Seasonal variability of number of farms whereby crops were reputedly destroyed by wildlife was investigated (Figure 2). The JJA season had the highest cases. This is attributable to the fact that during dry seasons the availability of food to both herbivores is reduced to the extent that they have to search for it beyond the boundaries of the national parks and hence result in destroying crops.

The years 1997 and 1998 had the lowest number of sites experiencing crop destruction. 201/2002 period had the highest cases. Graphical analysis suggests an increasing trend. This implies that other factors apart from weather, such as temporal increase in agricultural land due to increasing population, may be contributing to this observed trend. This requires further investigation.

Table 8 and Figure 7 indicates significantly negative correlation between Narok rainfall and crop destruction with lags of 1 and 3 seasons. This relationship is also important for planning purposes.

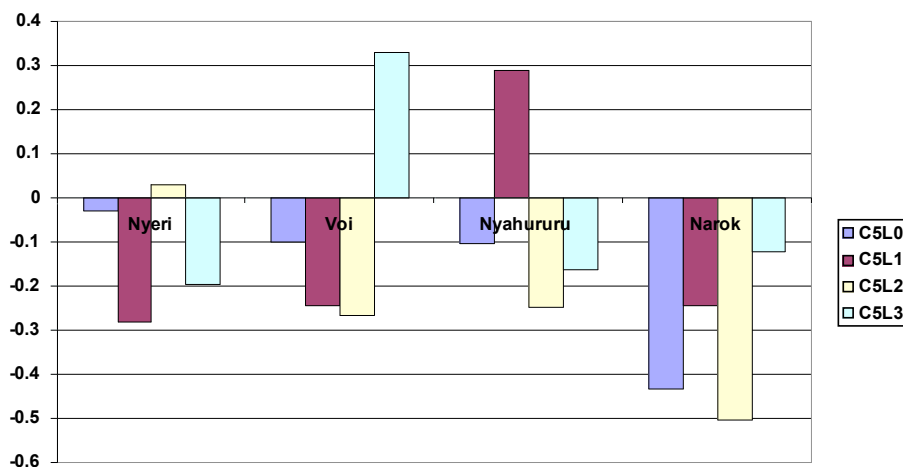


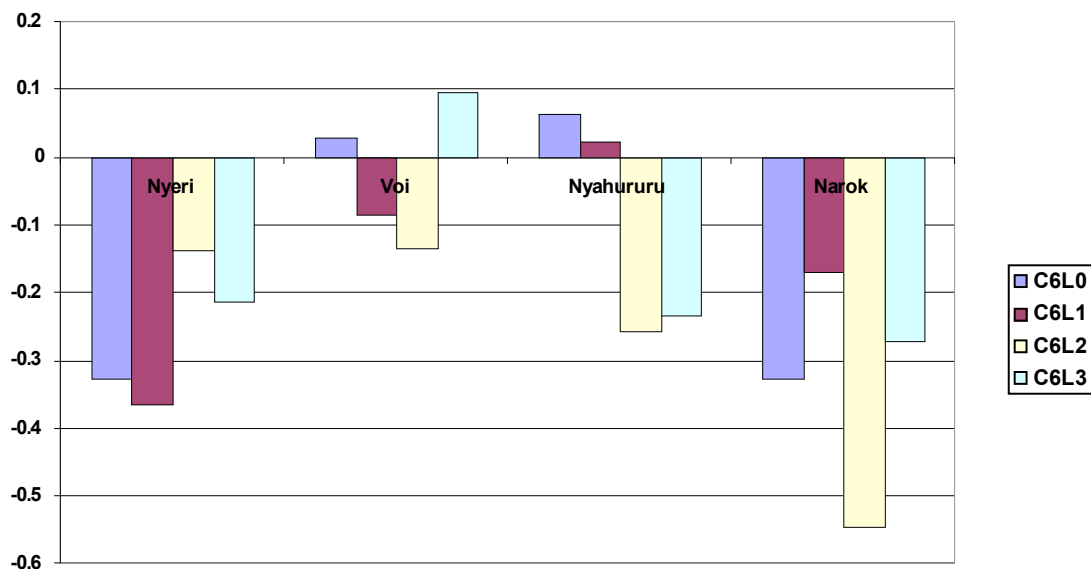
Figure 7: Crop destruction cases

### ***Number of affected sites***

Figure 1 shows that, with respect to analysis of seasonal variability of the number of sites where human-wildlife conflicts are reported, JJA had the highest number while DJF and SON had the lowest. This confirms the previous argument that dry seasons following, particularly poorly performing, rainy seasons trigger the movement of animals out of their confinements and hence result in human-wildlife conflicts.

Yearly variability of number of affected sites showed a peak in 2001 and 2002 while a minimum values was observed in 1998. This confirms the relationships previous discussed earlier.

Correlation analysis results indicated that rainfall at Nyeri and Narok is negatively correlated with number of affected sites (Figure 8). For planning purposes, this relationship, can be utilized with some skill.



**Figure 8: Number of affected locations**

## Analysis of homogeneous climatic zones

A comparative analysis of the four homogeneous climatic zones was undertaken, with respect to the six animal –humans conflict data ( $C_1$  to  $C_6$ ). The significant lag relationships were considered, ranging from lag zero ( $L_0$ ) to lag 3 ( $L_3$ ). For each homogeneous zone, relationship between rainfall over that region and lag correlation of each animal-humans data were obtained.

Narok, representing central Rift valley, showed the strongest relationship with  $C_1$  to  $C_6$  (Figure 9). Rainfall over this zone is significantly correlated with

- (i) count of different animal type, with a lead of two seasons (see  $C1L2$  in Figure 9),
- (ii) deaths of humans ( $C3$ ), with a lead of two seasons,
- (iii) crop destruction sites ( $C5$ ), with a lead of both zero and two seasons, and
- (iv) Number of affected sites, with a lead of two seasons respectively.

The fact that there is a significant relationship between rainfall and these three groups, whereby rainfall leads with two seasons is noteworthy. This suggests that Narok rainfall may be used as a signal of animal –human conflicts in Kenya.

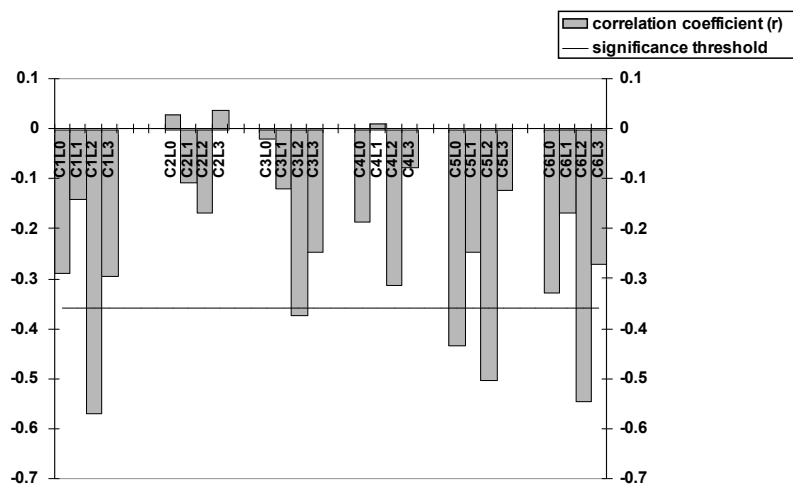
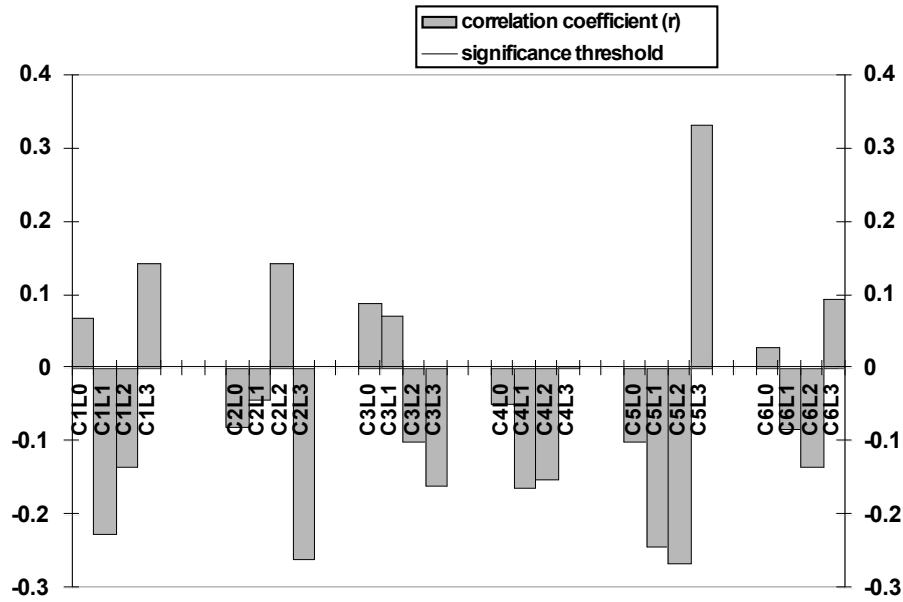


Figure 9: Central Rift valley (Narok)



**Figure 10: South eastern Lowlands (Voi)**

On the centrally, Voi, representing Southeastern lowlands, showed the least relationship with these data groups (Figure 10). No correlation existed between rainfall and C to C6. (Figure 10). This suggests that there is need to further investigate each homogeneous zone particularly using longer data length.

## Conclusion

The processes of actual usage of the relevant disseminated and understandable forecasts by KWS in non-existent. However, the issue of human-wildlife conflicts is seen as ranking high in the weather related factors of importance to KWS.

Results of temporal variability of some human-wildlife conflict parameters showed that the variability of the number of types of animals involved in these conflicts is dependent on rainfall. Also the number injuries and deaths of both human beings and domestic animals follow rainfall patterns. In addition, the number of site whereby crops are destroyed by wildlife, together with the cases of crop destruction, is also weather sensitive. The dry season of JJA seems to be the most sensitive one to these human-wildlife conflict parameters.

Analysis of the relationship between the dynamics of these conflict parameters and rainfall indicated that rainfall at Nyeri and Narok is negatively correlated with all the parameters except the death of humans, with rainfall leading with at least three months. In deed Narok rainfall seems to have potential of being used as an index for human-wildlife conflict resolution in Kenya. These relationships can, therefore, be further quantified with an aim of projecting them forward in time with reasonable skill. Such modeling will prove to be useful for factoring in rainfall information into the planning process of the KWS.

## **Way Forward**

A survey of the economic impact of weather on wildlife and Tourism industries is being undertaken. It is expected to completed in a month's time.

The development of capacity and mechanisms to incorporate climate forecasts and outlooks into the Institutional working framework of KWS and Tourism industry need to be undertaken. This will enhance operational applicability of the above reported results.

## Research Team

Name of Researcher:	Qualification:	Profession:	e-mail
<sup>1</sup> Dr. N. J. Muthama	Ph.D. (Environmental Meteorology) [Project Manager]	Environmental Meteorologist	jmuthama@uonbi.ac.ke
<sup>2</sup> Mr. J. M. Githaiga	M. Sc. (Zoology)	Ecosystem Ecologist	jmgithaiga@uonbi.ac.ke
<sup>3</sup> Mr S.M. Manegene	B.Sc. MSc (Planning)	Head Planning Section (KWS)	

## Address:

<sup>1</sup>Department of Meteorology, University of Nairobi, P. O. Box 30197, Nairobi.

<sup>2</sup>Department of Zoology, University of Nairobi, P. O. Box 30197, Nairobi

<sup>3</sup>Kenya Wildlife Services (KWS), P. O. Box 40241, Nairobi.

## Appendix

1997				
	DATE	Summary	LOCATION	REMARKS
1	6/1/1997	Crocodile kills 13-Yr old girl.	Usenge beach lake Victoria.	
2	21/1	Leaders appeal to Govt.	Chakama, Malindi.	Crocodiles maimed 20 people annually. Compensation. Not more than Sh. 300
3	22/1	Boy's tragedy	Sidonge, Busia.	Killed by crocodile.
4	29/1	Schoolboy killed by crocodile.	Athiriver	
5	10-Feb	Elephant kills girl in forest	Loosuk, Samburu	10-Yr. old girl . Gone to fetch wood.
6	20/2	Stray elephant kills woman.	Mariwenyi village, Mwatate Division Taita Taveta district.	KWS personnel shot animal dead.
7	23/2	Boy killed by crocodile.	Ziwani sublocation, Garissa, Tana River.	Had gone to fetch water, 10-Yr old.
8	2-Mar	Crocodile victim in hospital	Funyula, Busia	Had gone for a bath; rescued by a pupil 31 Yrs.
9	22/3	Lions, rhinos invade village	Kasemeni, Msambweni, Kwale.	Killed 26 goats and 2 cows.
10	24/3	2 injured	Merti, Isiolo	Lion attacked Manyattas

11	7-Apr	Hyena injures 5 Villagers living in fear of a beast	Lokori, Turkana	Attacked people in a Manyatta
12	24/5	Compensation rate unrealistic	Murengeti , Limuru	Leopard killed 5 sheep
13	26/7	KWS told	Mbeere	Death Ksh 30000,injury Ksh 15000, Bfw 1995-1997, 10 pple have been killed by wildlife
14	8-Aug	Giant cats go on the rampage	Marsabit town outskirts	Pride of 8 lions-80 heads of cattle eaten in 2 weeks.
15	26/9	Trader boy injured by rogue elephant	Kerwa, Limuru	Animal shot dead by game rangers.
16	7-Oct	Beast kills 100 sheep.	Ainabkoi, Uasin Gishu	Unknown killer killed a total of 100 sheep
		Rogue elephants on rampage	Tuegu , Nyeri	Destroyed maize and vegetables worth Ksh. 10 000

1998

DATE	SUMMARY	LOCATION	REMARKS
15/4 17/4	Anger over jumbo menace Beast strikes	OI Pajeta Ranch&sweet waters camp	Had killed 5 locals in 1995 and destroyed crops.
7-May	Jumbos invade field	Central Kenya	Broken show perimeter fence; fed on bananas, pawpaws,pumpkins and potatoevvines further show
22/5	Farmer killed in a bid to chase away elephants	Ntirititi, Meru	Herd of Jumbos
5-Jun	Wildlife menace halyts learning	Mkongani, Kwale	Elephants, lion, etc roaming area 2000 pupils affected 400 acres of crop destroyed in May
13/6	Battle in the wild to save man, 50	Nairasirara, Narok	102 goats killed by leopard crop destroyed by ellephants,buffaloes, zebras and antelopes
18/6	Farmers protect us from animals	Mwaluphomba, Kwale	More than 500 acres of cropro destroyed by elephants
25-Jun	Crocodile klls man at dam	Kikoneni, Kwale	4 people killed since 1988.
9-Jul	Crocodile havoc	Athiriver , Makueni	4 people killed in past 1 month
11-Jul	Animals destroy crops in Keiyo	Keiyo	Elephants destroy hudreds of food crops

18-Jul 15/8	Hippo destroys crops Plea on killer 16 killed in game attacks- report	Kawala, Mariakani West Uyoma,Bondo	Destroy cops,threaten lives Crocodile kills 2 people 16 killed, 17 injured between 1993- 1997.
2-Sep		Mau forest	In 1995 KWS spent Ksh 248 581 in compensation. 2 injured, animal killed
5-Sep	Buffalo injures pupils	Machakos town	
2-Oct	Warden killed	Kipkewa Forest, Kericho	1 killed, 1 injured by elephants.
1999			
DATE	SUMMARY	LOCATION	REMARKS
10/1/200			
27/1	3 Lions kill two men Jumbos attack	Diss, Wajir Marmanet, Laikipia Regege, Luduvai, Kimala- Taveta	2 killed, 20 cattle herds killed Attacked villagers Lion has now killed 5 goats, an 1 cow
29/1	Man mauled	God Abuoro, Nyando	3 sheep, 3 dogs killed
30/1	Hyenas kill sheep		
23/2	Beast menace	Sericho, Isiolo	2 killed by wild animals
21/3	Jumbo kills woman	Ngaremara, Isiolo	
20/4	Man escapes hippo attack	Kidinyanguo,Mariakani	Suspected that hippos are 2
6-May	Woman hurt in jumbo attack	Marura, Laikipia	About 3 jumbos killed os far by villagers by elephants
19-May	Killer jumbos traced	Nessuit forest,Njoro	2 elephants killed 2 men
19-May	Marauding beast hurt 4 people	Kinangop	Beast suspected to be hippo
20/5	Lion menace	L. Nakuru national park Mt Kenya	20 cows killed so far
29/6	Man killed by elephant	forest,Kirinyaga	1 killed, 1 injured
8-Jul	Hyena menace	Chemase, Nandi	Terrorises People and animals 1 injured
17/7	Marauding elephant kill man	Thoome, Laikipia	2 killed so far by about 6 Jumbos
1-Sep	Jumbo wreak havoc in Taita	Rekeke, Challa, Jipe Taveta	100's of acres of crop destroyed
5-Sep	Hyenas kill 17 cows	Lologo, Marsabit	17 cows killed for 2 months

13/9	Residents want KWS to act on rogue jumbos	Mwaluphamba, Kinango Kwale	more vthan 40 acre s of crop destroyed
19/9	Hippo menace	Near Lake Naivasha	Destroy farms
2000			
DATE	SUMMARY	LOCATION	REMARKS
26/1	Help us , farmers tell Govt. Varsity cashier killed by jumbos	Golini , Mwalupamba-Kwale	Elephants destroy crops
7-Feb	Woamn, 30, injured in lion attack.	Marmamet, Laikipia	
11/4/2003		Dureve, Narok	
19/4	Stray jumbo kills woman in village	Kanyaga, Tharaka	A pregnant woman
26/5	Man trampled to death by elephant	Morijoy, Narok	Lions and buffaloes are also many in the area
24/6	Chief shot in leopard rescue	Soi, Uasin Gishu	6 injured by 2 leapards
8-Jul	Rogue elephant kills 6	Rumuruti, Turkana	Fed on 1 1/2 acre farm valued at Ksh 20 000. Also destroyed crops worthy Ksh 300 000
10-Jul	Woman killed by hyenas	Chemase, Nandi	2 killed so far by elephants
28-Jul	Elephants trample villagers to death	Mackinon road , Kwale	
4-Aug	Elephants kill farmer	Loitokitok, Kajiado	40 farms destroyed
9-Aug	Couple killedby hyena	Manolo River valley, Kwale	Others killed 5 chicken, 3 goats injured 300 goats and sheep killed in 2 months following drought.
29-Aug	Hungry baboons now target goats	Mukogodo, Laikipia	100 buffaloes destroy 100's of acres of crop
10-Oct	Buffaloes damage crops	Kabendera	
7-Dec	Rogue elephant kills 2 villagers	Nyandarua	
30-Dec	Hippo mauls man in lake	Kisumu	

2000

DATE	SUMMARY	LOCATION	REMARKS
30/12	Rogue hippos kills Kisumu fisherman	Kisumu	
28/12	Narok hyena mauls 2 children ,injures mother	Ewaso Nyiro river, Narok	Also killd some livestock
12/12/2000			
3	Crocodile kills girl 5	Nguluku,Kwale	
12-Dec	Hyenas maul boy	Shimbiri, Garissa	killed also 6 camels 31 goats
	Jumbos spark anger in	Kirimara Chugu-Meru	
24/11	Meru	cenral	1 killed, crops destroyed
22/11	Hippo attack	Kuria	
	Elephants kill twomin		
26/10	Maralal	Maralal, Samburu	Herd of elephants
	Jumbos invade Mwatate		more than 100 elephants destroy
25/10	farms	Mwatate, Taita-Taveta	crops
			more than 100 baboons destroy
13/10	Babons raid Migori village	Suna North, Migori	crops and search for chicken
	Jumbos invade Narok		
21/9	farms	MorijoiSiyapei-Narok	
19/9	Man injured in hippo attack	Wachokoni, Hola	
	Girraffes ,birds invade	Uasin-Gishu	
8-Sep	farms	parts/areas	Quellea quellea birds
	Elephants wreck havoc in		Killed a boy-Nyandarua,Farms
30/8	Nyandarua, Laikipia	Nyandarua&Laikipia	destroyed-Laikipia
	Five Mandera women		
30/8	wounded by monkeys	Garba, Khole, Mandera	
	Hyena mauls couple to		Water shortage the problemAlso
9-Aug	death	Golini, Kwale	injured a boy .
			Villagers were keeping vigil at
			farms at night against wildlife
			Destroy 200 acres of maize &
4-Aug	50 buffaloes destroy maize		potatoes
	farms	Maela, Naivasha	
	Jumbos roar into trading	Salama,Rumuruti,	
29/7	centre	Laikipia	200 elephants

2001

DATE	SUMMARY	LOCATION	REMARKS
18/1	Hippos kill 2 children	Athiriver Kitui	
19/1	Animals kill girl and woman	Nzombo, Mwele, Kwale	Woman killed by buffalo Girl killed by elephant
17/2	Elephant kill 4 in rampage	Guwahati	
15/3	Girl saved from crocodile's jaws	Yolomuni, Kitui	
6-May	Contain elephants farmers tell KWS	Madunguni, Gede, Mijimboni Malidi	20 elephants destroyed maize, coconut, bananas & cassava plantations.

22/6	Buffalo kills woman	Hell's gate, Naivasha	
4-Jul	Thousands face starvation	Kilifi	20 elephants, 15 buffaloes invaded farms. Destryed 52 palm trees, 16 mango trees, 60 cassava plants etc valued at more than Ksh 500 000 120 goats and sheep killed
18-Jul	Leopard attacks	Polong'a , Narok	
22/7	Elephants kill man	Kahorora, Kericho	
12-Aug	Tourist killed by elephant	Tsavo East National Park	
15-Sep	Woman killed by crocodiles at river	Funyula , Busia	
3-Oct	Boy 15 is killed by crocodile goats	Sigor, West Pokot	
23/10	Man 50, is killed by buffalo	Singorai, Nakuru	

2001

DATE	SUMMARY	LOCATION	REMARKS
26/11	marauding wildlife plagues Kangudo	Areas around Donyo Sabuk game park	Roque hippos and buffaloes
23/11	Man trampled Angry residents kill 3	Baawa, Samburu	
17/11	elephants in revenge	Rumuruti, Laikipia	
8-Nov	Jumbo kill man 600 elephants invade	Rumuruti, Laikipia SHIMBA HILLS AREAS	30 elephants
25/12	farms Taveta jumbos destroy	Wundanyi, Taita Taveta	150 jumbos destroyed 100's of hectares of crops
19/12	crops Rein in these rogue	Moi Otiende , Ngei	
15/12	baboons in Lang'ata	Phase 1 estates	number more than 20 More than 100 elephants invade farms
13/12	Crops destroyed	Voi, Taita Taveta Uyawi, Wagusu and	
27/10	Hippos kill 6 in Bondo in 3 months	Liunda beaches- Bondo	Also disrupted fishing activities for more than 300 fishermen Destroyed crops worth 1000's of Kenya shillings
26/10	Hippo menace	Athiriver ,Kangudo	
12-Oct	Tourist mauled	Ndololo, Voi-Taveta Ndonyo Sabuk national park	Mauled by hyena
10-Oct	Buffalo menace	Kangudo	Destroyed farms
9-Oct	3 killed by rogue hippos	Chakama, Sabaki	

	in Malindi	river, Malindi	
27/9	DC warns on rogue jumbos	Laikipia	People kill them
25/9	Buffaloes destroy Mathira farms	Gitunduti, Nyeri	Groups of 30 animals destroy huge acres of maize & cabbage
14/9	Jumbos invade maize farms	Ndindika, Mwenje & Wangwachi-Laikipia West	Wreck havoc on maize & wheat farms
13/2	Monkeys invade farms in Kieni, destroy crops	Kieni East Nyeri	
3-Feb	Hyena mauls girl to death	OI Moran, Laikipia	
20/1	WILDLIFE MENACE	Wajir	300 livestock killed-drought
14/11	Jumbos wreck havoc	Ng'arua & OI Muran - Laikipia	Destroy crops
DATE	SUMMARY	LOCATION	REMARKS
4/1/2003	Boy trampled	Akiriemet, West Pokot	Jumbo provoked by cattle more than 600 elephants cause havoc
1-Jun	Demo over jumbo killing	Rwathia, LAIKIPIA	200 palm trees destroyed
12/1/2003	40 jumbos loose residents in protest over rogue elephants	Matsangani, Kilifi	
16/1	Hippos destroy crops in Nyando (KENYA TIMES)	Kainuk, Turkana	200 jumbos destroyed crops
18/1	Deserted elephant kills 10 (THE PEOPLE)	Nyakach, Nyando	Man killed, wife misses death
18/1		India	
27/1	Elephants wreck havoc	Rumuruti, Laikipia	10 acre orange farm destroyed. Man killed.
5-Feb	Jumbo kills one, injures another	Lologoriani, Transmara	crops also destroyed
15/2	Buffalo kills man in lake Jipe	L. Jipe, Taita Taveta	He was herding
2-Mar	KWS to give Ksh 23 million	Laikipia	Ksh 23 million for 3 months. Area has 2500 elephants
7-Mar	Destructive jumbo killed	Rumuruti, Laikipia	20 stores destroyed
20/3	Jumbos raid Kerugoya school	Mutige sec. school, Kirinyaga	1 man injured
30/3	Alert as jumbos invade Kabarnet	Kituro Forest	search for food and water
26/4	Baboon terror	Got Regea, Yala, Siaya	Cause havoc and destruction to property
7-May	Lions kill 36 ostriches in farm attack	Kitengela, Kajiado	Value Ksh 1 million last August, 12 ostriches mauled valued at Ksh 280,000 and 113 goats, 9 cows, 3 donkeys and 8 dogs.
10-May	200 jumbos terrorise Wundanyi residents	Mghaghe, Taita Taveta	several hectares of crop destroyed
22/5	Leopards kill herders, camels	Ngaroni, Samburu	killed, 2 people, 23 camels
31/5	Hippo attack	Manguo, Nyahururu	
10-Jun	Lion shot dead	Musinga, Voi	Killed 53 sheep, 7 goats, 1 dog